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81- FOI-238

WSEG REPORT NO. 23

THE RELATIVE MILITARY ADVANTAGES OF MISSILES AND MANNED AIRCRAFT

6 May 1957

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255

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TABLE OF CONTENTS

FIGURES

[redacted]

TABLES

[redacted]

[redacted]

WSEG REPORT NO. 23

THE RELATIVE MILITARY ADVANTAGES OF MISSILES AND MANNED AIRCRAFT

STATEMENT OF THE PROBLEM

1. To prepare a report, assuming reasonable success in carrying out the plans for the IRBM and ICBM, which would set forth the relative military advantages (excluding psychological considerations) of these missiles in comparison with manned aircraft and with non-ballistic missiles assumed to be available at the same time.[1/]

SCOPE AND ASSUMPTIONS

2. The military advantages of medium and long-range missile systems and manned aircraft are considered as they relate to the operations of strategic deterrence and retaliation within the concept of general war. No consideration is given to limited degrees of warfare falling short of general war, since it is considered herein that the IRBM and ICBM have no important use in such situations. It must be borne in mind, however, that many of the other systems considered, particularly manned aircraft, have essential uses in these types of war -- giving them in this respect an essential advantage over the ballistic missiles in question. On the other hand, general war is regarded here very broadly: in order to understand the military potentialities of a weapon system on a scientific basis, the most unlimited war situation in which it has a potential use must be considered, not restricted by any present date limitations of national policy. This has, among other things, the advantage of showing what the potential enemy could do against us by means of the same weapon system.

1/ JCS Memorandum to Director, WSEG, SM-290-57, dated 11 April 1957, SECRET.

[redacted]

[redacted]

3. The delivery systems considered are:

a. Ballistic missiles: ICBM (ATLAS, TITAN), IRBM (THOR, JUPITER), FBM (POLARIS);

b. Aerodynamic missiles: Intercontinental -- NAVAHO, SNARK; intermediate range -- MATADOR B, REGULUS II, and TRITON.

c. Manned aircraft: B-47, B-52, B-58 (with and without powered pod), A3D, A4D, and A3J.

4. In evaluating their capabilities, all delivery systems are considered on a common basis: the assumption that the published plans for producing them and the engineering forecasts of their characteristics are reasonably and equally successful.[2/] Furthermore, no attempt is made at an independent evaluation in these regards.

5. The time period involved is that of the operational availability of the first generation ICBM, IRBM, and FBM. It is assumed that the other delivery systems listed above can be available in the same period. The period so defined is estimated as between 1961 and 1967, although the accuracy of this estimate does not have in itself a major effect on the conclusions.

6. Finally, it is assumed that there are in existence in the time period considered early warning systems capable of

2/ The assumption of reasonable success of the scheduled engineering characteristics affects, for the most part, all the systems equally and does not produce any relative discrepancies. There is, however, one exceptional case: JUPITER's high predicted accuracy when brought into connection with hard point targets (paragraph 43). This possible exception has not been specified in the general conclusions of this study. If the results of this alone were reflected in the conclusions they would indicate that JUPITER is the most promising weapon for development. WSEG believes there is insufficient evidence to warrant such a decision at this time.

detecting approaching missiles and aircraft, and a communication system able to transmit information and commands between the warning system, missile and aircraft bases, and the command posts.

DISCUSSION

7. See paragraphs 23 to 31.

CONCLUSIONS

GENERAL

9. Ideally, a weapon system to be employed in the counterforce role should have a suitable CEP/warhead yield combination, fast reaction and fast delivery time, low susceptibility to destruction by surprise attack, high penetration capability, and good over-all operational flexibility. No single weapon system programmed will have all of these characteristics:

a. Manned aircraft have the required accuracy and payload capabilities, and constitute the only system considered which has the desired operational flexibility. However, because of their slow delivery time, decreasing penetration capability, and increasing base vulnerability, their utility in the counterforce role will progressively decrease.

b. Ballistic missiles will provide a very large improvement in the combined reaction/delivery time and in penetration capability, and a potentially large improvement in base invulnerability. However, the CEP/yield combinations of the first generation missiles are

inadequate for the destruction of the large number of hard military targets which will exist. Also, their effectiveness will depend to a great extent on the quality and completeness of the guidance and targeting data.

c. Aerodynamic missiles encompass a broad range of penetration capability, vulnerability, accuracy, and payload. Generally speaking, the supersonic missiles of this family have better penetration capability and shorter delivery time than manned aircraft. However, they lack the operational flexibility inherent in manned aircraft, and their accuracy/payload combinations are inferior. As compared to ballistic missiles, the aerodynamic missiles have better accuracy/yield combinations, but their delivery times and vulnerabilities will always be higher.

b. Deficiencies in accuracies and payloads of first generation missiles against small hard military targets limit their utility for other than a supplementary role to manned bomber systems for attacking such targets in the time period under consideration (1961 to 1967).

c. The best means of attacking a heavily defended, complex target system during the time period under consideration is with a combination of manned aircraft and ballistic and non-ballistic missiles. Employed in the proper balance, they can:

[redacted]

(1) Complement one another: - Weapons can be assigned targets for which they are individually best suited.

(2) Have a reinforcing effect: - The attack by manned aircraft can be preceded by the disruptive effect of missile attacks.

(3) Complicate the enemy's defense problem: - The diversified attack would impose upon the defender a far more complex problem from the standpoint of early warning and active and passive defense. It is probably true that an active defense system against ballistic missiles will not defend against manned bombers. The converse is, of course, also true.

d. The required level of attacks upon the large number of military targets and their cumulative effects may well be sufficient, in this time period, to cause the destruction of the political and economic centers, as well.

This is not expected to occur in the time period under consideration.

12. Because of the over-riding importance of weapon system survival capability, of fast reaction and rapid delivery time to counter the enemy's growing capability to launch larger strikes in shorter time, it is considered that a significant improvement of our military posture lies in the exploitation of the growth potential of ballistic missiles.

13. a. To insure the continued effectiveness of our deterrent forces, it is necessary that a sufficient fraction of these forces be in systems which have a very low susceptibility to destruction by surprise attack and which retain a capability for effective retaliation. The threat presented by these forces alone must be greater than the enemy is willing to accept to achieve his political aims. This high degree of invulnerability to surprise attack can be achieved through improved reaction time, dispersal, and hardening of our land-based systems, and by taking greater advantage of the mobility and concealment inherent in sea-launch systems.

Failure so to progress might tempt a test of our strength and intentions.

c. Deterrence in limited war, though very important, is not discussed in this report.[3]

3/ The foregoing principles and conclusions have been deduced primarily in their application to general war In a limited war, in remote or peripheral areas, a greater requirement for flexibility, versatility, and accuracy of delivery of weapons would most probably exclude the employment of long-range missiles and most of the intermediate-range ballistic and non-ballistic missiles of the type considered in this study. Greater dependence would be placed on families of shorter range weapons and manned aircraft deliveries. As explained in paragraph 2, the subject is not discussed in this report.

SUMMARY OF THE MILITARY ADVANTAGES AND DISADVANTAGES OF THE VARIOUS WEAPONS

Manned Aircraft

14. The principal military advantages of manned aircraft are:

a. Operational flexibility,

b. Accuracy of delivery,

c. High payload capacity,

d. Established reliability,

e. Reconnaissance capability.

15. The disadvantages are:

a. Decreasing penetration capability,

b. Increasing base vulnerability,

c. Long flight time,

d. Increasing system costs.

Ballistic Missiles

16. All of the strategic ballistic missile systems have the following general military advantages:

a. Very high penetration capability,

b. Potentially low base vulnerability,

c. Short flight time,

d. High growth potential.

17. The disadvantages are:

a. Relatively poor operational flexibility,

b. Low delivery accuracy,

c. Low payload capacity.

18. Within the family of strategic ballistic missiles, there are important military advantages and disadvantages of each:

a. ICBM (located within continental U.S.)

(1) Advantages

(a) No dependence on foreign bases,

(b) Short logistic support lines,

(c) High system security.

(2) Disadvantages

(a) An attack upon the system draws fire on the U.S.

b. IRBM (land-based)

(1) Advantages

(a) Will provide earliest strategic ballistic missile capability,

(b) Most favorable CEP/yield combination.

(2) Disadvantages

(a) Dependence on foreign bases.

c. FBM (submarine-launched)

(1) Advantages

(a) Lowest susceptibility to pre-planned surprise attack,

(b) An attack upon the system draws little fire on the U.S. and none on Allies,

(c) No dependence on foreign bases.

(2) Disadvantages

(a) Relatively late system availability.

Aerodynamic Missiles

19. Aerodynamic missiles encompass a broad range of penetration capabilities, mobility, and accuracy. The comparison of military advantages and disadvantages of the various systems within the family is as follows:

a. Intercontinental Systems

(1) NAVAHO

(a) Advantages

(i) Excellent penetration capability,

(ii) Good payload capacity,

(iii) Short flight time,

(iv) Not susceptible to ECM.

(b) Disadvantages

(i) High system cost,

(ii) Slow reaction time,

(iii) Lowest reliability.

(2) SNARK

(a) Advantages

(i) Lowest system cost,

(ii) Earliest availability,

(iii) Good payload capacity.

(b) Disadvantages

(i) Poorest penetration capability,

(ii) Low growth potential,

(iii) Slow reaction time.

b. Medium Range Systems

(1) MATADOR B

(a) Advantages

(i) Transportable,

(ii) Lowest system cost,

(iii) Highest accuracy,

(iv) Good payload capability,

(v) Quickest reaction time,

(vi) Diversified penetration capability,

(vii) Relatively early availability,

(viii) Highest system reliability.

(b) Disadvantages

(i) Low growth potential,

(ii) Dependence on foreign bases,

(iii) Long flight time.

(2) TRITON

(a) Advantages

(i) Excellent penetration capability,

(ii) Very high accuracy,

(iii) Good payload capacity,

(iv) High base mobility and concealability,

(v) Growth potential,

(vi) No dependence on foreign bases,

(vii) Short flight time.

(b) Disadvantages

(i) Highest system cost,

(ii) Slow system reaction time,

(iii) Lowest system reliability,

(iv) Relatively late system availability.

(3) REGULUS II

(a) Advantages

(i) High accuracy,

(ii) Good payload capacity,

(iii) Base mobility and concealability,

(iv) No dependence on foreign bases.

(b) Disadvantages

(i) Decreasing penetration capability,

(ii) Slow system reaction time,

(iii) Low system reliability,

(iv) High system cost.

RECOMMENDATIONS

20. That a mixed system of ICBM's, IRBM's, manned aircraft and aerodynamic missiles be developed for employment by the U.S. during the period 1961-1967.

21. That missile sites and air bases be hardened and dispersed to the maximum extent possible. This may involve removal of radio-guidance antenna in favor of all-inertial guidance systems.

22. That WSEG be authorized to review this report one year hence in the light of technological and other developments during the year.

DISCUSSION

23. The first part of this Discussion will be devoted to a formulation of the general requirements that strategic deterrence imposes upon weapon systems. In case deterrence fails, the weapon systems are required to have the ability to attack a variety of target types. The second part of the Discussion accordingly treats targeting considerations against the general background of the various delivery systems. The third and concluding part of the Discussion is concerned with the military advantages of the various systems in situations of deterrence or general war.

GENERAL REQUIREMENTS FOR OUR FULL SYSTEM OF WEAPONS

24. In the general strategic situation which gives the terms of reference to this study, our over-all system of weapons is required to have two functions: The first is to deter the enemy from launching war on us, by maintaining a retaliatory capability in being. The second function, which operates in case deterrence fails and a general war starts, is to maximize the chance of survival of our population and national strength by striking the enemy's system of weapons and power and will to fight. The two functions are different and impose requirements on the weapon systems that are sometimes the same and sometimes different. To understand the bearing that this has on our choice of weapons, the general requirements for strategic deterrence and for striking the enemy's weapon system will now be spelled out.

Requirements for Strategic Deterrence

25. The requirements for strategic deterrence are:

a. The ability to inflict damage on targets of primary interest to the enemy's national strength such as his military, political, economic, and industrial centers and larger geographical areas.

b. This damage to be sufficiently massive to outweigh any conceivable advantage that the enemy might expect to gain by the use of his military power against us.

c. The ability to strike with sufficient force in spite of an enemy's attack, delivered with or without warning, and in the face of active and passive defensive measures on his part. Furthermore, strategic deterrence must not contain its own countermeasure by having its use so physically detrimental to us or to our friends that we would be the less likely to use it.

d. The will to use our military power under appropriate circumstances to be evident to our potential enemy; no reliance to be placed on deceiving him in such regard.

Requirements for General War

26. The requirements for general war are:

a. In case the war starts by a surprise attack launched by the enemy, we require the power of destroying whatever of military power remains as a further threat.

b. In case the start of the war does not take us by surprise, we require a system for striking every element of the enemy's military strength, with first priority in time and importance given to those weapons that are directed against us first.

Over-all Requirements

27. There are general requirements for performing both the above functions. The first is that our over-all system of weapons must have the ability to respond to our political intentions with minimum constraint of their mode of use by physical limitations. This is promoted by:

a. Flexibility: A strategic weapon system has to exist, exert its deterrent function, and ultimately operate in a political environment, which may in the course of world events call for varying orders of threat and graduations of deterrence.

b. Proof Against False Triggering: There should be nothing in the physical characteristics of a deterrent weapon system itself that could lead to its precipitate use. It should be capable of deliberate use, without suffering any important degradation.

28. A further general requirement is the maintenance of a dynamic advantage over the enemy's weapon systems, never trusting a momentary superiority but having an ever-developing program to anticipate change with change.

TARGETS, WARHEADS, AND DELIVERY SYSTEMS

29. Having discussed the general requirements for a full system of weapons, a second preliminary step will be taken in establishing the relative military advantages of missiles and other delivery systems, the warheads which are carried and the targets against which they are delivered will be examined against the background of the characteristics of the various delivery systems.

Characteristics of Delivery Systems

30. Table I lists pertinent characteristics of the weapon systems considered in this study. The performance figures for manned aircraft are taken from the references noted on the Table, as is the missile data, which represent the best available estimate of performance and weapon yield.

Targets and Weapon Effects

31. Principal targets in a general war are listed by function in Table II.

[redacted]

TABLE I

CHARACTERISTICS OF VARIOUS WEAPON SYSTEMS

[redacted]

[redacted]

	BALLISTIC MISSILES			
	ICBM ATLAS/TITAN	IRBM JUPITER THOR	FBM POLARIS	MATADOR B
MAXIMUM RANGE (MISSILES) RADIUS (A/C) (n. mi.)	5500	1500	1500	1500 at 40,000' 550 at 1000'
ALTITUDE d/ (ft.)	680 n.mi.	320 n.mi.	300-400 n.mi.	500-40,000
SPEED (Mach)	23	16	16	.9
PROPULSION	Liquid Rocket	Liquid Rocket	Solid Rocket	Turbojet
GUIDANCE	Radio-inertial or All inertial	Radio-inertial or All inertial	All inertial	Inertial-ATRAN
ACCURACY (CEP)				
WARHEAD e/ (MT)				

a/ Performance figures for manned aircraft are taken from: USAF Green Book, Standard Aircraft Characteristics," 15 March 1957; and USN "Characteristics Summary, U.S. Navy Aircraft," and information provided by OPNAV (OP-551). Missile data is based on "Black Book" information provided to the OASD(R&E) by the three Services, dated January 1957.

b/ USAF aircra
low altitud
is incorpor

c/ Radius of t
25 per cent

[redacted]

[redacted]

TABLE I

CHARACTERISTICS OF VARIOUS WEAPON SYSTEMS a/

NON-BALLISTIC MISSILES

B	SNARK	NAVAHO	REGULUS II	TRITON	B-47	B-52	
000' 0'	5500	5500 3500 with increase payload	500 at M 2.0 1000 at M .94	1200	4545 b/ (2 refuelings)	5520 b/ (2 refuelings)	(2 In M
	52,000	80,000-90,000	60,000-70,000	70,000	37,350	45,600	52 M
	.94	3.25	.94 - 2.0	2.7	.74	.78	2
	Turbojet	Rocket-boosted Ramjet Cruise	Turbojet	Rocket-boosted Ramjet Cruise	Turbojet	Turbojet	
AN	Stellar-inertial	Inertial	Inertial	Inertial-ATRAN	--	--	

educed range)

F aircraft ranges are for high altitude profile. The altitude profile is not given but the significance incorporated in the body of the report.
ius of these carrier aircraft can be extended approximately per cent by one refueling.

d/ Altitude given for bal trajectory. Altitude craft is altitude for
e/ The lower value of wa value. The upper valu the time period under

[redacted]

MANNED AIRCRAFT

B-47	B-52	B-58	A3D-2	A4D-3	A3J-1	Powered B-58 POD
4545 [b] (2 refuelings)	5520 [b] (2 refuelings)	2940 [b] (2 refuelings) Incl. 200 n.mi. M 1.5 dash	Unrefueled [c] 1550	Unrefueled [c] 940	Unrefueled 1050 (with 300 n.mi. dash at M 1.3)	60 Class B whd 100 " C whd 150 " D whd
37,350	45,500	52,000 with M 2 Dash	37,200	37,500	51,000	105,000
.74	.78	.93 Cruise 2.0 Dash	.89	.89	.9 Cruise 1.3 Dash	4.0
Turbojet	Turbojet	Turbojet plus Afterburner	Turbojet	Turbojet	Turbojet plus Afterburner	Liquid Rocket
--	--	--	--	--	--	Inertial

d/ Altitude given for ballistic missiles is apogee for maximum range trajectory. Altitude for non-ballistic missiles and manned aircraft is altitude for high altitude run-in on target.

e/ The lower value of warhead yield for missiles is the programmed value. The upper value represents the growth potential within the time period under consideration.

[redacted]

TABLE II

TARGETS

Military	Strategic	Missile Sites Aircraft Runways Aircraft (sheltered and exposed) Command Centers Communication Systems
	Tactical	Ground-to-air missile Establishments Fighter-interceptor Establishments Troops Naval Units
	Logistic	Submarine Pens Naval Bases Hardened Storage Sites (particularly stockpile) Storage Dumps Oil and Other Military Industry Transportation
Political and Economic	City	Governmental Control Centers Population[a/]
	Industrial	Factories Storage Sites Transportation Systems Power Systems Mining Operations
	Rural Areas	Population[a/] Agriculture

a/ The consideration of the destruction of cities as well as of various civilian targets is relevant to the present Report notwithstanding certain formulations of general United States policy. The information is applicable to our own weapon systems under variable policies, and to our potential enemy's weapons when used against us. In the latter connection, it may be emphasized that the whole Report can perform the function of setting forth what we have to fear from an enemy making a rational use of a system containing ballistic and other missiles.

32. From the points of view of vulnerability and size, there are, as shown in Table III, four main classes of targets: small hard, small soft, intermediate soft, and large soft.

TABLE III

TARGET GROUPS

Size / Vulnerability	Small	Intermediate	Large
Hard	Missile Sites Aircraft Runways Sheltered Aircraft Command Centers Governmental Control Centers Submarine Pens Hardened Storage Sites (Stockpile)		
Soft	Industrial Aircraft on Field Ground-to-air Missile Establishments Fighter-interceptor Establihsments Electronic Ground Environment	Cities Communication Systems Naval Shore Establishments Troops	Geographic Area

33. The damage produced by a nuclear explosion is the composite result of blast, heat, prompt radiation, local radioactive fallout, and deposition of radio-toxic material (chiefly Sr^{90}) in the soil of the country attacked. (It is of course unnecessary to go into the qualitative and quantitative details of each of these effects in this place, since accounts of these are well known; cf. AFSWP TM 23-200, SECRET RESTRICTED DATA; also WSEG Staff Study No. 37, TOP SECRET, RESTRICTED DATA.)

34. In addition to these localized effects, there are world-wide results of the radioactive contamination of large portions of the earth's atmosphere and resulting widespread fallout, with potential danger from ingestion or, possibly, through genetic influence. While these effects are slight with presently contemplated scales of attack, they may not always remain so upon their increase, and should never be lost sight of. Moreover, locally, in the border regions of some of our Allies, such effects may reach dangerous proportions. They come, therefore, into focus under the requirement that a system should not contain its own countermeasure. And it must be emphasized that any agency of strategic retaliation will fall short of meeting this requirement to the extent that (in spite of its actual safety) our nationals <u>believe</u> that it probably constitutes a real hazard to ourselves.

35. Blast and earth shock are the most important weapon effects for the destruction of small targets, both soft and hard. For intermediate soft targets, blast and local fallout are the primary effects, with thermal radiation contributing to a lesser extent. The only significant effect on rural areas is fallout.

<u>Force Requirements of the Delivery Systems for Accomplishing Various Missions</u>

36. Table IV presents the number of successful weapons[4] of each type which must be delivered to accomplish each of four primary missions, chosen to represent the four major categories of targets. These missions are:

<u>a</u>. Destruction of a specified fraction of the population of a city.[5]

4/ For the purposes of this report, a "successful weapon" is defined as: a missile or bomb which has survived all enemy action and has had no launch, flight, or fuzing failures, and is subject only to the random delivery errors described by the CEP.

5/ See footnote <u>a/</u> to Table II, page 15.

[redacted]

TABLE IV

NUMBER OF SUCCESSFUL WEAPONS WHICH MUST BE DELIVERED TO ACCOMPLISH VARIOUS MISSIONS

[redacted]

[redacted]

[redacted]

3LE IV

: BE DELIVERED TO ACCOMPLISH VARIOUS MISSIONS

Destruction of Hard (100 psi) Point Target (Prob. of Destruction)					Delivery of 1000 MT (Fallout Mission)
.1	.25	.5	.75	.9	
12	34	80	160	270[b/]	See Footnote b/
1	1	2	4	6	
2	5	13	25	42[b/]	
4	11	26	52	86[b/]	
1	1	1	1	1	
1	2	5	10	16	
1	2	5	10	16	
1	1	1	2	3	
1	1	1	1	1	
1	1	1	1	1	
1	1	1	1	1	
1	1	1	1	1	
1	2	3	7	11	
1	1	1	3	4	
1	1	1	2	3	

[redacted]

TABLE IV

NUMBER OF SUCCESSFUL WEAPONS[a] WHICH MUST BE DELIV

Destruction of City Population (Expected Fraction Destroyed) .25	.5	.75	.9	Destruction of Soft (3 psi) Point Target (Prob. of Destruction) .1	.25	.5	.75	.9
2	4	7	12	1	1	3	5	9
1	2	3	5	1	1	1	1	1
1	2	4	6	1	1	1	1	2
1	2	5	8	1	1	1	2	3
1	2	3	5	1	1	1	1	1
1	1	2	3	1	1	1	1	1
1	1	2	3	1	1	1	1	1
1	2	3	5	1	1	1	1	1
1	2	3	5	1	1	1	1	1
1	1	1	1	1	1	1	1	1
1	2	3	5	1	1	1	1	1
1	1	1	2	1	1	1	1	1
1	2	3	5	1	1	1	1	1
1	1	1	2	1	1	1	1	1
1	1	1	1	1	1	1	1	1

successful weapon," see footnote 4/, page 17.

rement in certain places merely emphasizes that
as not built for that purpose and implies no
ystem.

[redacted]

WEAPON	Destruction of City Population (Expected Fraction Destroyed) .1	.25	.5	.75	.9
ATLAS/TITAN	1	2	4	7	12
JUPITER	1	1	2	3	5
THOR	1	1	2	4	6
POLARIS	1	1	2	5	8
MATADOR B	1	1	2	3	5
SNARK	1	1	1	2	3
NAVAHO	1	1	1	2	3
REGULUS II	1	1	2	3	5
TRITON	1	1	2	3	5
B-52/47/58	1	1	1	1	1
A3D/A4D/A3J	1	1	2	3	5
" " "	1	1	1	1	2
Powered B-58	1	1	2	3	5
" " "	1	1	1	1	2
" " "	1	1	1	1	1

a/ For definition of "successful weapon," see footnote 4/.

b/ The excessive requirement in certain places merely emph[illegible] the weapon system was not built for that purpose and im[illegible] derogation of the system.

[redacted]

b. Destruction, with a specified probability, of a soft (3 psi) point target.

c. Destruction, with a specified probability, of a hard (100 psi) point target.

d. Area fallout delivery.

The values in Table IV are based upon the weapon characteristics (CEP and warhead yield)[6] stated in Table I and upon weapon effects data from AFSWP TM-23-200. For area fallout, we have presented the number of weapons needed to deliver 1000 megatons. These numbers are to be interpreted in light of Figure 1 (based upon WSEG Research Memorandum No. 3) which shows the numbers of radiation casualties expected from well directed fallout campaigns.

37. We must emphasize that Table IV expresses solely the number of successful weapons which must be delivered in the target area. It specifically excludes important considerations such as system reliability, attrition due to enemy action, the time that is required to accomplish the mission, and the costs of the various sytems.

OPERATIONAL CONSIDERATIONS: QUICK RESPONSE

38. In order to develop the role of the various weapons considered with respect to the national defense, it is necessary to examine their use as a deterrent and their employment in war. The requirements for strategic deterrence have been treated earlier in the Discussion, and the relation of targets and warhead effects in the section just concluded. There remain the most severe requirements imposed by the need of striking back promptly at the enemy's military power with sufficient force.

[6] For weapons whose yield is uncertain, we have consistently chosen the lower yields of the ranges shown in Table I.

FIGURE 1

FALLOUT CAPABILITIES FOR
DELIVERY SYSTEM WITH CEP

[redacted] [redacted]

FALLOUT CAPABILITIES AGAINST USSR FOR DELIVERY SYSTEM WITH CEP ~

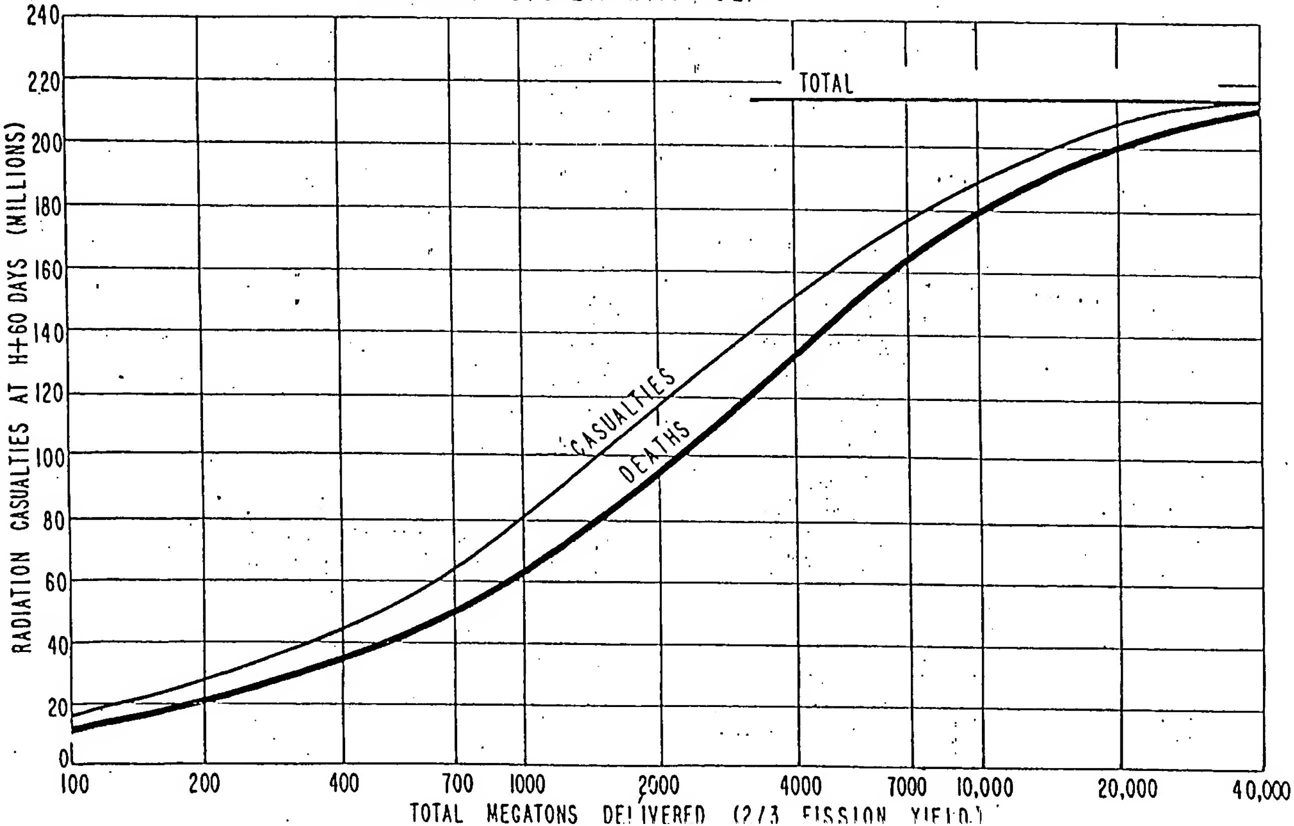


FIGURE 1
WSEG REPORT NO 23

39. During the time period of concern in this study the enemy will be unlikely to bring all of his weapons to bear against us in an initial concerted attack. He would be unlikely to get off all his ICBM's in the first wave. Some portion, which diminishes with time, will presumably remain uncommitted. Similarly, with manned aircraft and aerodynamic missiles, he is unlikely to launch his entire force in his opening strike. Since the preservation of our people and our national strength is of paramount concern, the task after an assumed first attack on us is to prevent further injury.

<u>Ballistic Missiles</u>

40. Because of the short time required for readying them following the execution order and their very short time of flight, ballistic missiles are eminently suited from a time standpoint for this initial task. But because of their comparatively low warhead yield and rather large CEP, ballistic missiles cannot be counted upon to do more than temporarily neutralize some of the categories of target shown in the list in the following paragraph. (This concept of neutralization will be set forth here and in succeeding paragraphs.) The period of neutralization can be sufficiently long in some cases, however, to allow time for manned bombers or aerodynamic missiles possessing better accuracy and carrying higher yield warheads to make their flight and attack in strength with a high probability of destruction, thereby minimizing the threat to the U.S. from follow-up strikes.

41. The principal elements of the enemy's remaining forces which would be involved in carrying out follow-up strikes are: Long Range Air Force command control centers, ICBM launching sites, aircraft staging bases, Long Range Air

Force home bases, governmental control centers, and national atomic stockpile sites. Timely and successful attack against all of these targets would guarantee the blunting of every major element of the enemy's remaining striking power.[7]

42. Long Range Air Force command control centers, governmental control centers, and national atomic stockpile sites are small, hard targets which, to be damaged, will require a rather large number of ICBM's. This is a result both of the hardness of the target and of the CEP of the ICBM. In the period under consideration the CEP of the ICBM is planned to be and the yield If we make the reasonable assumption that these targets are hardened so that 100 psi overpressure is required for their destruction, then, as shown in Table V (an extract of Table IV), for 50 per cent probability of destruction enough ICBM would need to be assigned to insure the delivery of 80 successful missiles.

43. An improvement in CEP to the accuracies planned for POLARIS, THOR, and JUPITER would markedly reduce the number of missiles required. From Table V it is noted that the numbers of successful weapons required for 50 per cent damage probability are, respectively, 26, 13, and 2. Even with their CEP of , POLARIS and THOR are not suited for employment against 100 psi targets. A realization of CEP for JUPITER would allow serious consideration of this missile for use against small, hard targets (See, however, footnote 2/, page 2. In paragraphs below, which deal with JUPITER, this matter will not again be mentioned.)

7/ With the exception of submarines and other naval units which are not considered here.

TABLE V

(EXTRACT FROM TABLE IV)

NUMBER OF SUCCESSFUL WEAPONS [a/] WHICH MUST BE DELIVERED TO ACHIEVE PROBABILITY OF DAMAGE INDICATED

	CEP	YIELD, MT	SMALL SOFT TARGET (3 psi) Probability of Destruction (%)					SMALL HARD TARGET (100 psi) Probability of Destruction (%)				
			10	25	50	75	90	10	25	50	75	90
ICBM (ATLAS, TITAN)			1	1	3	5	9	12	34	80	160	270
IRBM (THOR)			1	1	1	1	2	2	5	13	25	42
IRBM (JUPITER)			1	1	1	1	1	1	1	2	4	6
FBM (POLARIS)			1	1	1	2	3	4	11	26	52	86

a/ For definition of "successful weapon," see footnote 4, page 17.

44. The ICBM's compare more favorably with the other systems when their ability to neutralize the soft elements of air bases is considered. Staging bases and Long Range Air Forces are vulnerable mainly through their aircraft and through the effects of radiological contamination on personnel.

45. Disruption of the enemy's staging bases would mean that during the period wherein they were inoperative he would be restricted in delivering warheads by aircraft to the use of his heavy, long-range bombing forces. Medium bombers, which must stage in order to make round trips, would not be available to him during this interval. He could, of course, resort to one-way missions for mediums, but short of this type of employment the enemy's air threat to U.S. targets in terms of numbers of aircraft might be reduced by as much as 50 per cent.

46. Attacking the enemy's Long Range Air Force home bases would bring under attack some portion of the enemy's heavy bomber force. Aircraft on these bases could be temporarily immobilized, but it should be pointed out that significant numbers of them could have been deployed to alternate and satellite fields and consequently might escape the initial U.S. ICBM attack.

47. A blast overpressure will cause quite severe damage to bombing aircraft. This overpressure applied to an airfield will insure that any aircraft found on it will be unusable for a period sufficient to allow retaliating manned bombers to arrive and complete the airfield destruction.

48. This overpressure will also destroy any ballistic missiles which may be exposed on their launching pads and may damage the cranes used for positioning them.

49. A probability of 50 per cent of achieving the above type of damage to aircraft bases and unhardened ICBM sites is attained by assigning ICBM, to such targets so that three successful missiles are delivered. In the case of the IRBM a single successful missile is sufficient and will, in fact, result in greater than 50 per cent probability of damage.

50. We conclude from the above that it is appropriate to assign ICBM to the airfield and unhardened ICBM site targets and the IRBM and FBM to the control center targets.

Aerodynamic Missiles

51. An appreciation of the very important advantage mentioned earlier which ballistic missiles possess in timeliness of delivery over other delivery means is gained by a rough comparison of the times of flight involved. ICBM flight time for ranges in the neighborhood of 5500 n.mi. is about one-half hour while IRBM flight times for distances of 1500 n.mi. are about 15 minutes.

Subsonic missiles (SNARK) and bombing aircraft require even longer periods: from 6 to 12 hours when launched from U.S. bases. Airplanes of the era of concern flying from aircraft carriers will have maximum radii of approximately 1500 nautical miles and would require about 3 hours of flight to reach targets at this distance.

[redacted]

TABLE VI

FLIGHT TIME IN HOURS
OF SEVERAL DELIVERY MEANS
FROM CERTAIN BASES

SNARK				7	10
NAVAHO				2	3
B-47	3	4¼	5½	9	12½
B-52				8½	12
B-58[a]	1¾	2½	3¾	6½	9½

a/ B-58 assumed to fly supersonically while over enemy territory.

Neutralization

This planned rate of launch, plus short delivery time, gives the ballistic missile a unique advantage over all other means of warhead delivery in situations where quick reaction is a primary requirement. This advantage is one which ballistic missiles will maintain in the face of even marked advances in the performance of manned bombers and aerodynamic missiles.

54. In conclusion, during the initial period of the conflict when the requirement is for the fast delivery, the ballistic missile is the only vehicle which provides that capability. However, the destruction which it can accomplish is greatly limited by the large CEP of the early missiles. The major military mission of the ballistic missile at

[redacted]

[redacted]

this time must be destruction of soft bases and soft components of bases together with disruption at hard installations. The more complete destruction of hard enemy installations must be left for more accurate delivery vehicles.

OPERATIONAL CONSIDERATIONS: MASSIVE FOLLOW-UP STRIKE

55. The role of the ballistic missile in disrupting and retarding the enemy's efforts at mounting follow-up strikes is a vital and indispensable one, but is not in itself sufficient. There must be a subsequent attack in strength by vehicles which are capable through a combination of better accuracy and higher yield warhead of causing complete destruction of those elements of the enemy's striking power which remain unused.

Accuracy and Payload

56. In paragraph 43 was pointed out the number of successful ballistic missiles required for destruction of small, hard (100 psi) targets. The numbers of successful missiles required to achieve 50 per cent probability of destruction of such a target are 80 ICBM's, 26 POLARIS's, 13 THOR's, and 2 JUPITER's.8/

57. From Table IV of the preceeding section we note that the aerodynamic missiles SNARK and NAVAHO are able to achieve this result by delivering five successful missiles while in the case of the aerodynamic MATADOR a single successful missile suffices. Any of the manned bomber systems require successful delivery of but a single bomb. This disparity in the number of warheads required between the non-ballistic delivery means and the ballistic missiles

8/ Of course, these comparisons are only meaningful when targets attacked are within range of the intermediate range missiles.

[redacted]

is seen to be marked in the case of small, hard targets, but is also to be noted in the case of city population targets.

58. We conclude, therefore, that ballistic missiles are unsuitable for the destruction of the hard targets which constitute most of the elements of the enemy's unused striking power, by reason of the large number of them required, and that manned bombers and certain aerodynamic missiles are probably well suited to this task.

59. Table IV is valuable in that it affords an appreciation of the efficiency of the various weapon systems expected to be available in the time period under consideration. It does so by taking into account their load-carrying abilities as well as their estimated delivery accuracies, but it does not consider certain other factors which, taken with these two considerations, are necessary to the selection of an optimum weapon system for destruction of a particular type of target.

60. While we can derive from Table IV the conclusion that manned bombers and aerodynamic missiles are better suited to making the attack in strength which follows the initial quick ballistic missile strike, we must take into account factors other than accuracy and warhead yield when we attempt to point out the advantages of delivery means within these classes.

Vulnerability at Target

61. The manned bomber possesses the best accuracy and carries the greatest payload of any of the delivery means here considered. Its CEP is of the order of and the yield of its payload is sufficiently great so

[redacted]

[redacted]

that it is possible to equate one bomb with one target. Yet, because of the many factors (such as improvement in defense, etc.) which act to decrease the chance that a particular bomber in the inventory will ever deliver a bomb on a target within enemy territory, other weapon systems which are markedly inferior in the accuracy of their delivery and in yield of their warheads are able to compete with manned aircraft for employment against certain targets.

The defenses about these cities will be extremely strong and the expectation of survival of a bomber attemtping to penetrate them in order to arrive at a bomb release point may reach a rather low value. To insure that a single bomber would survive to drop its bomb might require an inordinate number of bombers in the inventory when compared with the number of aerodynamic missiles required to accomplish the same task.

63. Thus, the aerodynamic missile NAVAHO which carries a smaller yield warhead and which is capable of less accurate delivery than a manned bomber may nevertheless be a more appropriate weapon to use against targets of this type because of its better chances for survival. NAVAHO cruises at altitudes considerably higher than those of which the manned aircraft are capable and also cruises at a speed several times the speed of sound. The enemy will be required to make substantial improvements in those of his defenses designed to cope with subsonic and transonic bombers in order to upgrade their performance to a point where they can offer any significant threat to NAVAHO.

64. Due to the trend of increasing effectiveness of the defense relative to the ability of the manned bomber to defend itself, it may be expected that the usefulness of the manned aircraft in attacking heavily defended targets will decrease during the period of concern in this study.

This follows as a result of the accuracy with which a manned aircraft can deliver its warhead and the concomitantly fewer warheads required in comparison with other systems.

66. In a case such as this where the accuracy of delivery of the manned bomber is an order of magnitude greater than that of NAVAHO, the manned aircraft possesses an advantage which is not easily overcome by even a marked decrease in vulnerability.

67. Weapon systems, in the order of decreasing vulnerability at the target, are: subsonic vehicle; supersonic vehicle; and ballistic missile. Tactics such as flying low, electronic countermeasures, and decoys greatly reduce the vulnerability of the subsonic vehicle, while technological developments, especially in the surface-to-air missile systems, are likely to make the aerodynamic vehicles increasingly vulnerable. Ballistic missiles will remain practically invulnerable until 1965.

<u>Flexibility</u>

68. The great advantage of the manned bomber in comparison with any of the missiles is that it carries a human

intelligence. The requirement for human operators results in an aerodynamic performance penalty to the bomber, but there are nevertheless manifold advantages to be gained by their presence in an attack vehicle. Perhaps the most valuable aspect of the presence of human operators is that it allows reaction to conditions found in the target area which are different from those anticipated. Another very useful function that human operators perform is reconnaissance. They bring back evaluated information concerning bomb drop locations, target destruction, enemy defense dispositions, etc.

Vulnerability at the Base

69. In order to meet the requirement for survival of our military strength in the event of a surprise attack, a number of protective measures can be taken. These include the development of early warning with quick-launch or fly-away capability, and hardening or mobility of the launching bases. As a matter of fact, in the era when the enemy possesses a ballistic missile system comparable in accuracy to our own first generation system the most effective protection of our land bases is likely to be obtained by hardening and dispersal.

70. Ballistic and aerodynamic missile sites because of their cellular configuration can be more readily hardened and would therefore be less attractive as targets than conventional air bases. The very large number of ballistic missiles required to destroy a hardened missile site is indicated in Table V. (See column headed "Destruction of a Hardened Point Target" in the "ATLAS/TITAN" row.) This number is so large that it is unlikely the enemy would

attack such sites.[9/]

71. In contrast, the individual conventional air bases represent such concentrations of military force that it is almost impossible to protect them adequately so that they become unattractive targets. Even with the success of the alert force concept no more than of the force could get into the air prior to the arrival of ballistic missiles and no more than additional could take off prior to the arrival of manned bombers even if they were hardened.

72. The sea-launch systems utilize to a large extent mobility and/or concealment for their protection. Concealment, in the case of submarine-launch systems, makes them probably the most nearly invulnerable launching "bases" of any of our delivery systems.

COST

73. While it is true that the choice of a weapon system for attack of a particular target must in many cases be made primarily without regard to economic considerations, there are nevertheless many situations, all other things being equal, in which the choice is more appropriately made on these grounds.

74. A choice based on economic factors depends in turn upon a determination of force requirements to which cost estimates may be attached. The factors which enter into a determination of force requirements include:

a. Availability (or "in-commission") rates of aircraft and missiles.

b. Probability of surviving the initial enemy attack.

9/ We must caution that current plans do not call for hardening of early ATLAS sites. However, this decision may yet be changed. It is planned to harden all TITAN sites.

c. Abort rates.

d. Attrition rates due to enemy action.

75. In the case of manned bombers where our accumulation of experience is greatest there is felt to be a wide range of possible values for each of these factors. We have even less experience with aerodynamic missiles and experience is practically nil for ballistic missiles. This circumstance of uncertainty in the computation of force requirements dictates a cautious approach to comparisons among missile systems which are made on an economic basis. We shall make a few such comparison, but must warn the reader against drawing any but the broadest inferences from them.

76. In Figure 2 is shown a curve of "deliverability"[10/] as a function of the annual total system cost for the B-52 weapon system when the target is a small, hard target which must be destroyed with a 50 per cent probability. The cross-hatched area is bounded top and bottom by lines representing the costs of the NAVAHO weapon system when deliverability is respectively 0.2 and 0.5.

77. We note that if NAVAHO deliverability is 0.5, a value which might be attained after some experience has been gained in the missiles' use, the deliverability of the B-52 would need only have a value of 0.17 in order to yield the same annual systems cost. If B-52 deliverability is greater than 0.17, costs will be less than for NAVAHO for this target and a choice made in this case on economic grounds would be in favor of the B-52. If it fell below 0.17 while NAVAHO remained at 0.5 deliverability, the choice

10/ By deliverability is meant the chance that a single bomber or missile in the inventory will deliver a warhead on the target. Its value, of course, depends upon the assumptions made as to the values of the factors listed above which go to make up force requirements.

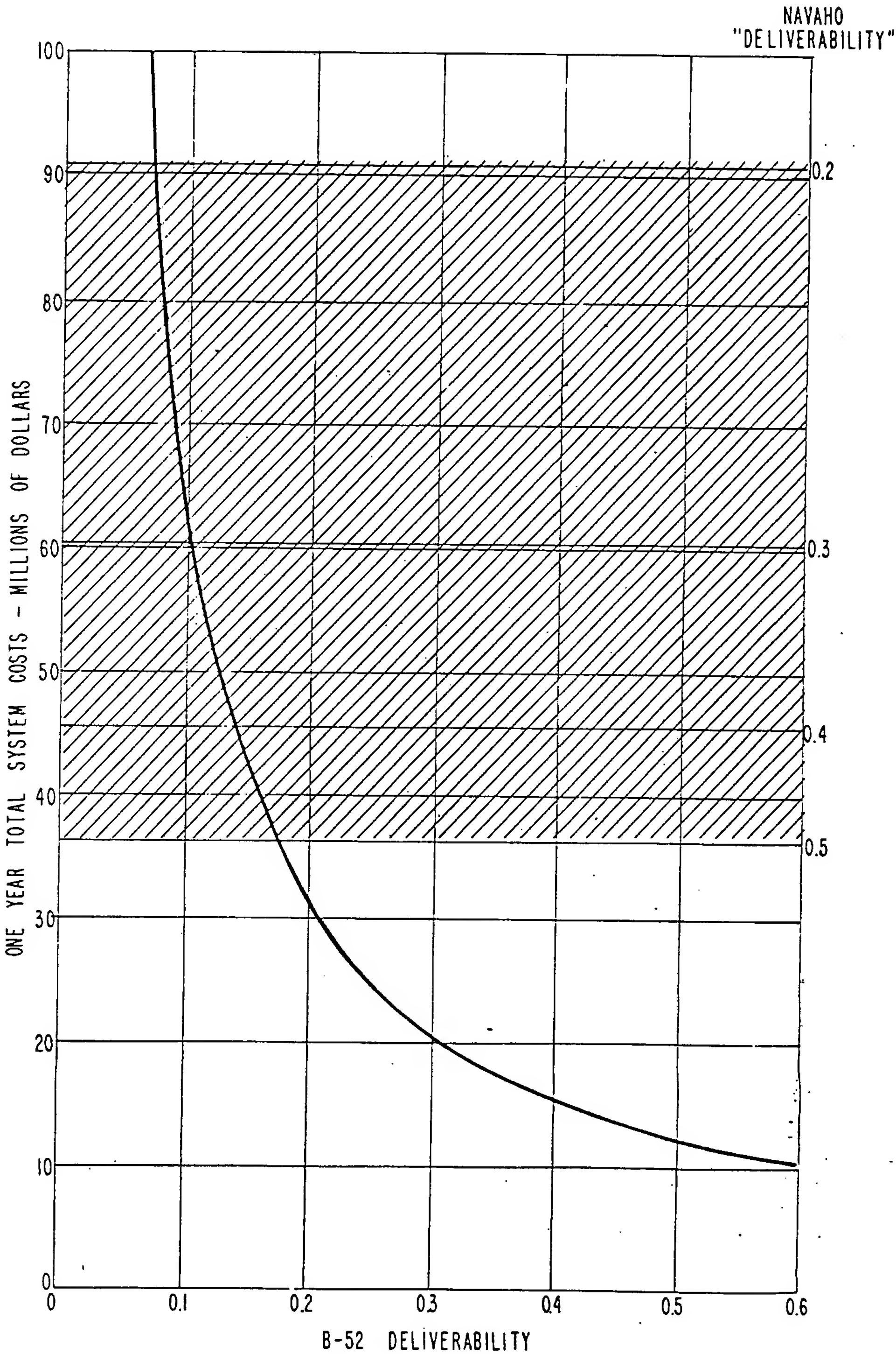
[redacted]

FIGURE 2

ANNUAL TOTAL SYSTEM COSTS FOR DESTROYING WITH 50% PROBABILITY A SMALL, HARD (100 PSI) TARGET

[redacted]

ANNUAL TOTAL SYSTEM COSTS FOR DESTROYING WITH 50% PROBABILITY A SMALL, HARD (100 PSI) TARGET



[redacted]

FIGURE 2
WSEG REPORT NO. 23

would be in favor of NAVAHO.

78. Of course, as NAVAHO deliverability decreases, B-52 deliverability has to become increasingly poorer in order for it to be displaced by NAVAHO. What the actual value of B-52 deliverability may be is of course very difficult to predict, but against a small hard target it would appear that the B-52 may retain an advantage over the NAVAHO.

79. Figure 3 is similar to Figure 2 but applies to the case of a political or economic center, that is, a population target. In this case the NAVAHO probably would have a decided advantage over the B-52 from an economic viewpoint.

80. The B-52 might also be displaced by ATLAS in the case of this type of target because the expected strong defense of population centers would result in a minimum value for B-52 deliverability.

81. These examples are offered as illustrations of how, when more complete information becomes available, it may become possible to make decisions on economic grounds.

FIGURE 3

ANNUAL TOTAL SYSTEM COSTS FOR EXPECTED DESTRUCTION OF 50% OF POPULATION IN A CITY TARGET

[redacted]

ANNUAL TOTAL SYSTEM COSTS FOR EXPECTED DESTRUCTION OF 50% OF POPULATION IN A CITY TARGET

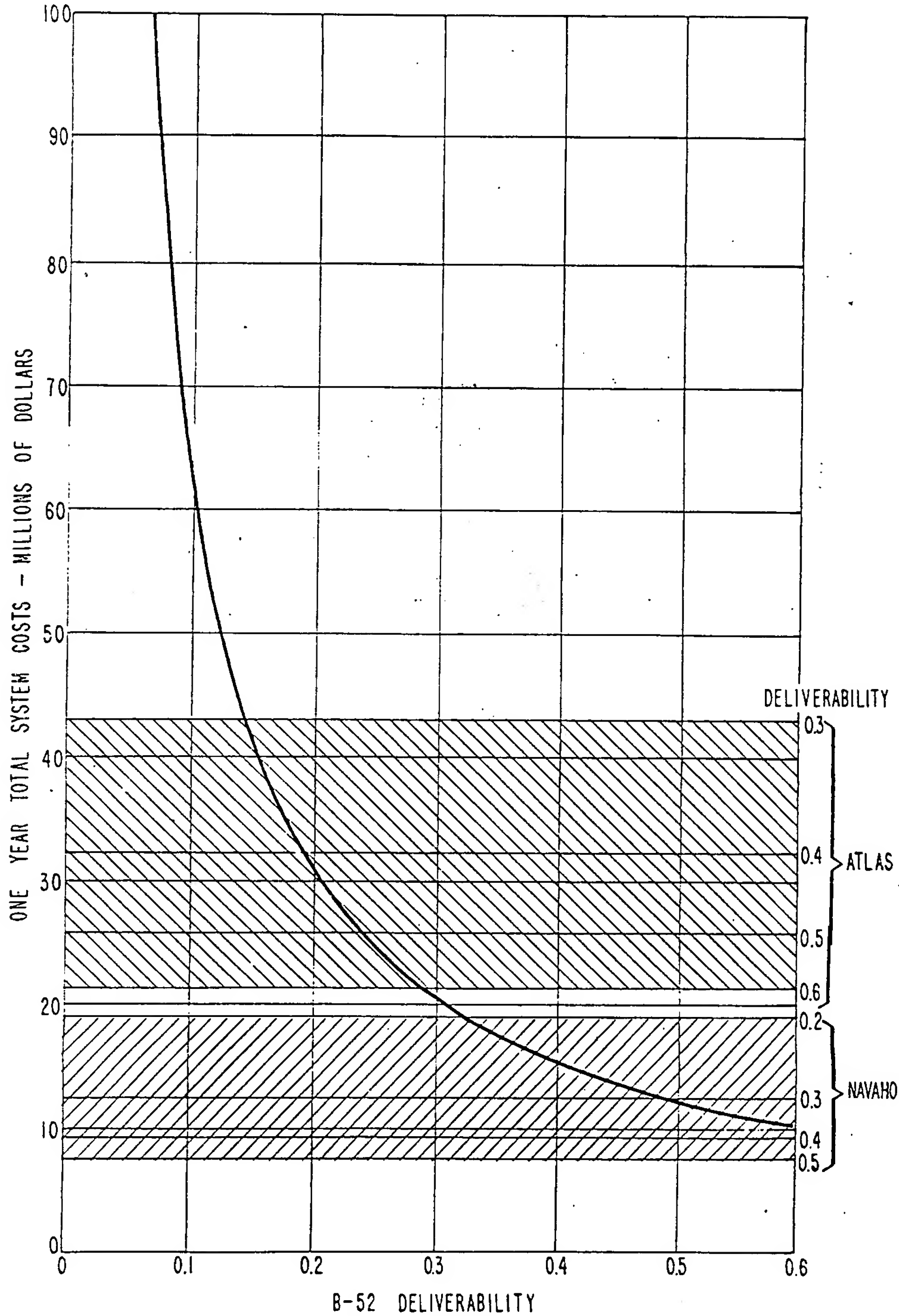


FIGURE 3
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